# Demonstration Gas Ring Cooler Lattice

**Al Garren**

**Gas Ring Workshop, BNL, June 28-29, 2004**

**May 18, 2004**

## History:

**Tucson and pre Oxford:**

Showed weak focusing and FFAG scaling lattices and simulations with them.
Showed realistic fields and orbits for 4-sector ring
Adopted weak focusing ring designs.

**Oxford Miss.**

Reported simulations with 200, 400, and 800 Mhz RF
Adopted 201.25 Mhz, 1.8T
Tentatively adopted 6-cell ring

**Oxford to BNL meeting:**

Examined (lattice and simulation) 4, 6, and 8 sector rings-with certain variations-for 201.25 Mhz, 1.8T, and integral harmonic number.
Tentatively confirmed 6-cell ring choice.
Made realistic fields and orbit calculations for 6-sector ring, with two vertical gaps.
Considered septum, kicker muon-beam injection and proton > pion > muon injection

## Lattices studied of rings for 201.25 Mhz, 1.8T, with integral harmonic number h.

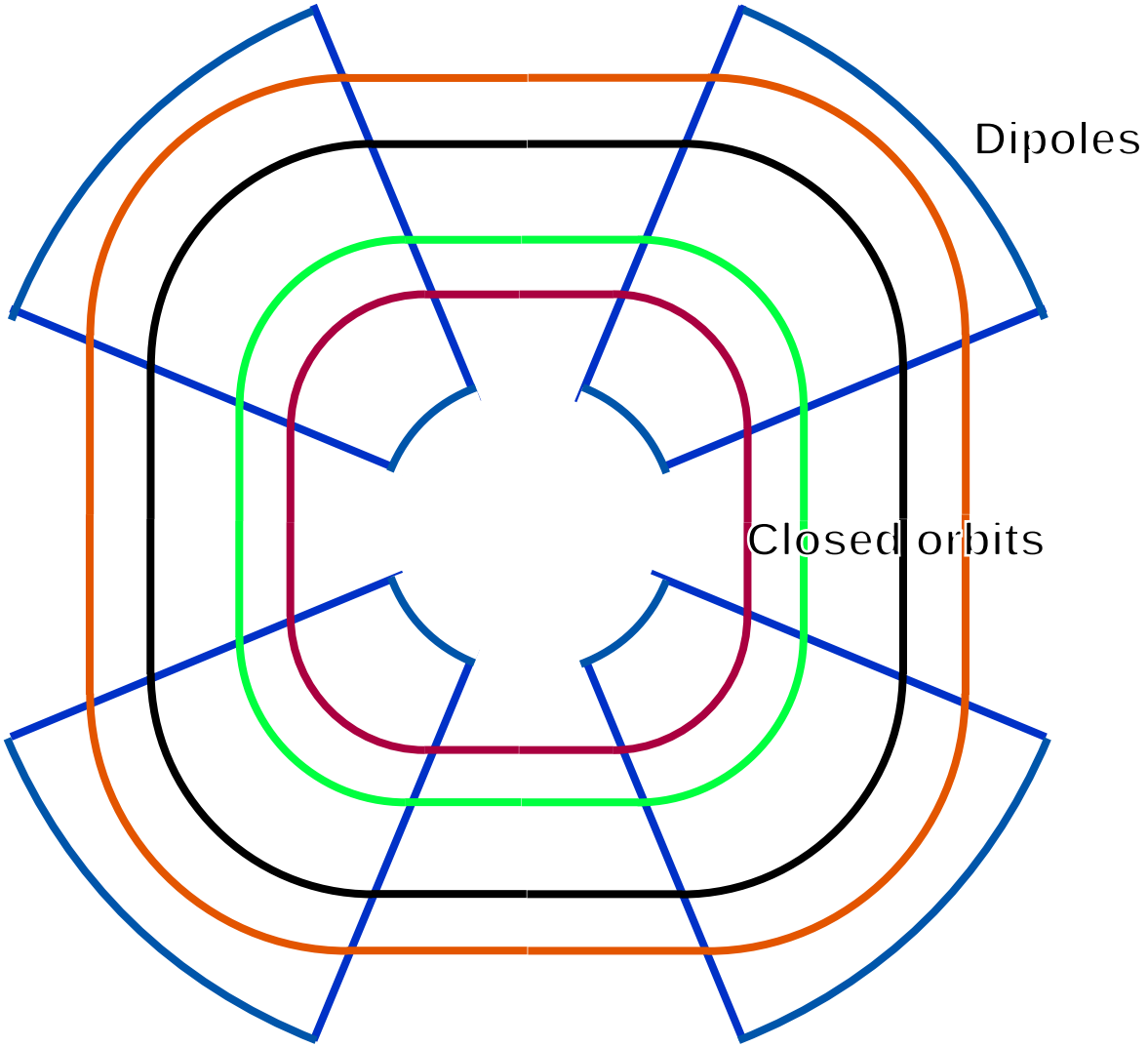
4, 6, 8 cells

$\lambda = 0.9, 1.0, 1.1$

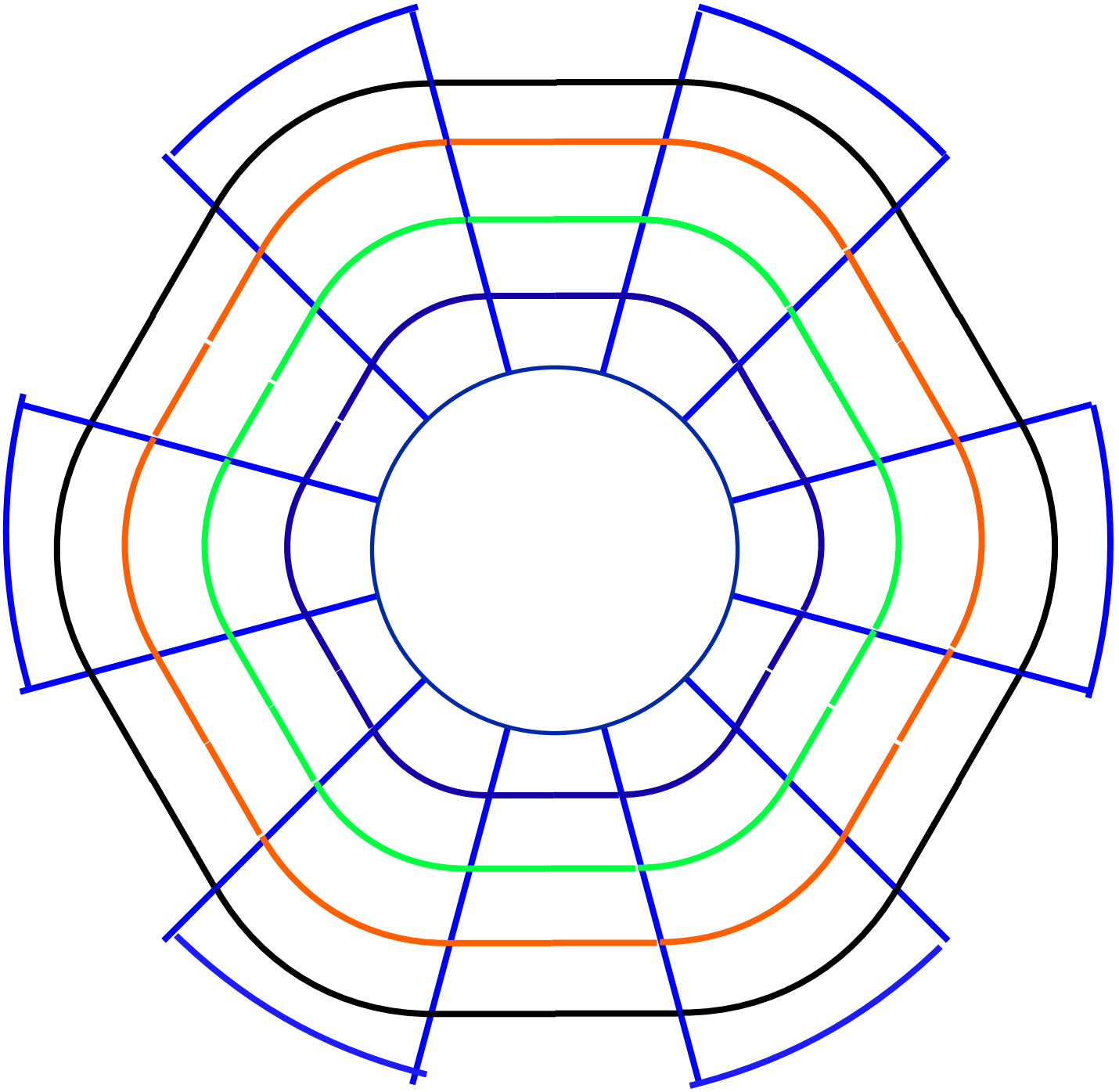
$h = 2, 3, 4$

gradient = 0, 0.11T/m

# 4-DIPOLE WEAK-FOCUSING RING
## $\lambda = \rho / Rc = 1$



# 6 DIPOLE RING



# CELL OF 4–CELL RING

$\lambda = \rho / Rc$

$\sigma = (1+\lambda^2+2\lambda\cos\theta)^{1/2}$

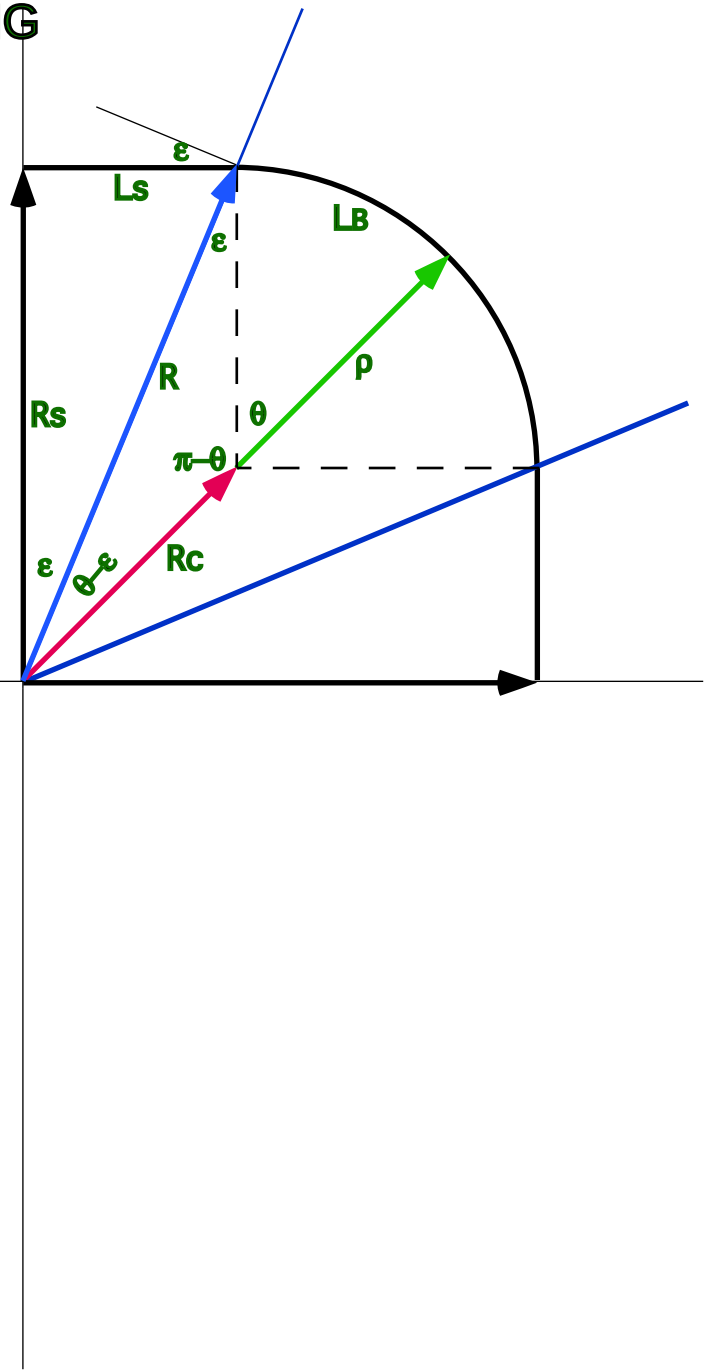
$R = Rc\ \sigma$

$\varepsilon = \sin^{-1}(\sin\theta / \sigma)$

$Rs = R \cos\varepsilon$

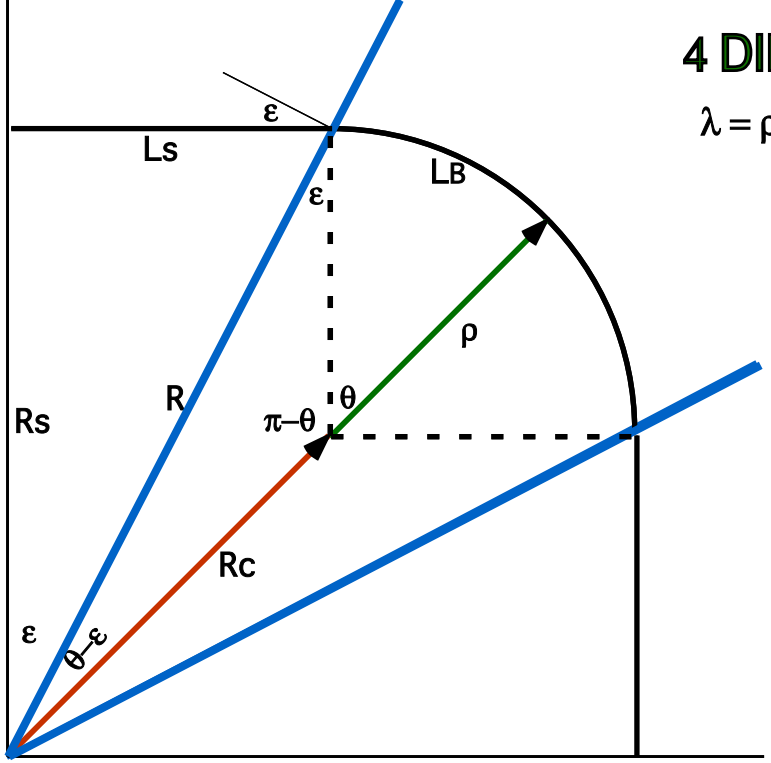
$Ls = R \sin\varepsilon$

$LB = \rho\,\theta$



# 4 DIPOLE RING

$\lambda = \rho / Rc = 2/3$



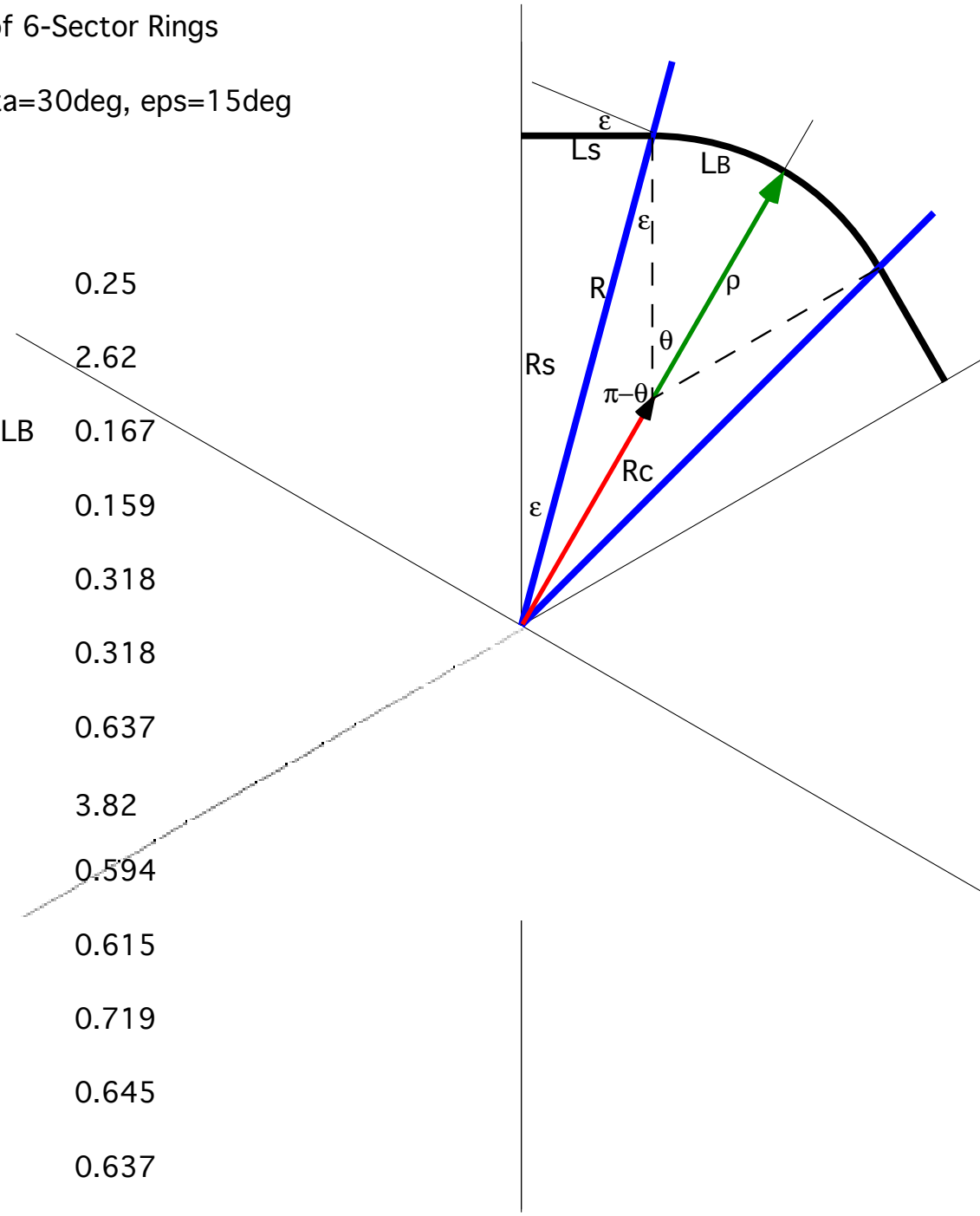
# 6 DIPOLE RING

$\lambda = \rho / Rc = 1$

Parameters of 6-Sector Rings

rho=Rc, theta=30deg, eps=15deg

| | |
|---|---|
| Momentum, GeV/c | 0.25 |
| Magnetic field, T | 2.62 |
| Magnet half length LB | 0.167 |
| Gap half length LS | 0.159 |
| Rho | 0.318 |
| Rc | 0.318 |
| Cell length | 0.637 |
| Circumference | 3.82 |
| RS | 0.594 |
| R | 0.615 |
| Bx, max | 0.719 |
| By, max | 0.645 |
| D, max | 0.637 |



# Cooler Ring Lattice Parameters

| x | 4-cell | 6-cell | 8-cell |
|---|---|---|---|
| **Harmonic number** | 3 | 3 | 3 |
| **$\lambda = \rho$ / Rc** | 1 | 1 | 1 |
| **RF frequency (Mhz)** | 201.25 | 201.25 | 201.25 |
| **Momentum (MeV/c)** | 172.1 | 165.5 | 163.2 |
| **Relative energy $\gamma$** | 1.9115 | 1.8554 | 1.8401 |
| **Transition energy $\gamma$t** | 1 | 1 | 1 |
| **Relative velocity $\beta$** | 0.8522 | 0.8421 | 0.8394 |
| **Magnetic field (T)** | 1.7999 | 1.7963 | 1.8003 |
| **Circumference (m)** | 3.8086 | 3.7635 | 3.7514 |
| **Dipole length (m)** | 0.501 | 0.3208 | 0.2375 |
| **Drift length (m)** | 0.4511 | 0.3062 | 0.2314 |
| **Radius to center curv. Rc** | 0.319 | 0.3064 | 0.3024 |
| **Radius of curvature $\rho$** | 0.319 | 0.3064 | 0.3024 |
| **Radius at drift center** | 0.5445 | 0.5717 | 0.5817 |
| **Radius at magnet center** | 0.638 | 0.6128 | 0.6048 |
| **Cell tunes $\mu$x** | 0.2774 | 0.1732 | 0.1276 |
| **$\mu$y** | 0.2573 | 0.1687 | 0.1258 |
| **Beta maxima $\beta$x** | 0.9158 | 0.6918 | 0.6442 |
| **$\beta$y** | 0.6593 | 0.6205 | 0.6089 |
| **Dispersion maximum D (m)** | 0.638 | 0.6128 | 0.6048 |

# Cooler Ring Lattice Parameters-variations of λ and gradient

| x | 6-cell | **6-cell** | 6-cell | 6-cell |
|---|---|---|---|---|
| **Harmonic number** | 3 | 3 | 3 | 3 |
| **λ = ρ / Rc** | 0.9 | 1 | 1.1 | 1 |
| **Gradient (T/m)** | 0 | 0 | 0 | **0.1101** |
| **RF frequency (Mhz)** | 201.25 | 201.25 | 201.25 | 201.25 |
| **Momentum (MeV/c)** | 153.4 | 165 | 163.2 | 165 |
| **Relative energy γ** | 1.7629 | 1.8554 | 1.9453 | 1.8554 |
| **Transition energy γt** | 1 | 1 | 1 | 1 |
| **Relative velocity β** | 0.8236 | 0.8421 | 0.8578 | 0.8421 |
| **Magnetic field (T)** | 1.8004 | 1.7963 | 1.8007 | 1.7963 |
| **Circumference (m)** | 3.6804 | 3.7635 | 3.8333 | 3.7635 |
| **Dipole length (m)** | 0.2976 | 0.3208 | 0.342 | 0.3208 |
| **Drift length (m)** | 0.3158 | 0.3062 | 0.2969 | 0.3062 |
| **Radius to center curv. Rc** | 0.3158 | 0.3064 | 0.2969 | 0.3064 |
| **Radius of curvature ρ** | 0.2842 | 0.3064 | 0.3266 | 0.3064 |
| **Radius at drift center** | 0.5577 | 0.5717 | 0.5837 | 0.5717 |
| **Radius at magnet center** | 0.6 | 0.6128 | 0.6235 | 0.6128 |
| **Cell tunes μx** | 0.1739 | 0.1732 | 0.1726 | **0.1928** |
| **μy** | 0.1783 | 0.1687 | 0.1605 | **0.1488** |
| **Beta maxima βx** | 0.6835 | 0.6918 | 0.6983 | 0.6373 |
| **βy** | 0.5774 | 0.6205 | 0.6618 | 0.7038 |
| **Dispersion maximum D (m)** | 0.6 | 0.6128 | 0.6235 | **0.4987** |

**We have identified one lattice that is most promising from the standpoint of cooling performance. By exploring a number of lattice variations and simulating their performance with ICOOL, we feel we have confirmed this. But this selection has perhaps not yet been vetted sufficiently for practicality or optimality in the light of magnet design, rf, injection and other requirements. In this workshop we hope to illuminate further some of these requirements and choices.**